FOOD, REPRODUCTION AND ORGANIC CONSTITUTION OF THE COMMON ANTARCTIC ECHINOID STERECHINUS NEUMAYERI (MEISSNER) [1]

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Studies have been made on the reproduction and nutrition of regular echinoids of California (Lasker and Giese, 1954; Bennett and Giese, 1955; Giese *et al.,* 1958; Boolootian *et al.,* 1959; Giese, 1959, 1961; Holland and Giese, 1965). The general findings have been in accord with similar studies on other echinoids of temperate and tropical regions (Hyman, 1955, pp. 461–506; Harvey, 1956; Nichols, 1964; Giese *et al.,* 1964). The biology of polar echinoids, which live in an environment where light and phytoproduction are markedly seasonal and temperature is constantly near freezing, has remained virtually unknown, largely because of the difficult working conditions. The establishment of a permanent biological laboratory at McMurdo Station, Antarctica (79°S., 166°E.) (Wohlschlag, 1963) has made possible the work on a polar sea urchin, *Sterechinus neumayeri,* presented in this paper.

Sterechinus neumayeri (Meissner), one of the regular echinoids (Echinidae), is among the most common animals in shallow water of McMurdo Sound (Dearborn, 1965). However, because McMurdo Sound is covered with sea ice most of the year, specimens of *S. neumayeri* are difficult to collect. Only 37 specimens of *S. neumayeri* were obtained for this study from McMurdo Sound during samplings throughout 1961. Although this sample is small it proved adequate to provide some basic information on the food, reproductive periodicities and organic constitution of this echinoid, which is presented here for comparison with work previously done on echinoids of temperate and tropical regions.

Materials and Methods

The specimens of *S. neumayeri* used for this study were collected from Cape Royds (77°33′S., 166°07′E.), Cape Evans (77°38′S., 166°24′E.) and Turtle Rock (77°45′S., 166°46′E.) in McMurdo Sound off the southwestern coast of Ross Island, Antarctica. These collecting localities have been previously described

[1] Supported in part by NSF-G-13209, NSF-G-18021 and NSF-G-73 grants to Dr. D. E. Wohlschlag from the Office of Antarctic Programs, and by U. S. Public Health CA 03461 grant to Dr. A. C. Giese. Logistic support in McMurdo Sound was provided by the U. S. Navy Task Force 43 under the command of Adm. David M. Tyree. We are indebted to Drs. Donald E. Wohlschlag, John H. Dearborn, Jack L. Littlepage and Nicholas D. Holland for much aid and advice, to Dr. Richard A. Boolootian for having the histological sections prepared, and to Dr. Roger Cornell and Miss Janet Lind for doing most of the biochemical analyses. The Stanford Computation Center did many of the calculations for the values given in this paper.

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(Pearse, 1965). The number of animals collected at each locality and the date of each collection are given in Table II. Most of the specimens were taken with a dipnet from 1 to 3 m. depth, either through cracks in the sea ice, or while wading, or from a small pneumatic raft when the sea was free of sea ice cover (January to mid-April). Specimens of *S. neumayeri* were difficult to collect between mid-April and December when the sea ice solidly covered the southern part of McMurdo Sound. However, on November 11 one animal was taken by dipnet from the leading edge of the sea ice cover at Cape Royds and on December 7 another animal was snared in a trap set through a hole cut in the sea ice at Cape Royds and a third was similarly captured at Cape Evans.

The animals were transported in insulated gallon jugs to the nearby biological laboratory at McMurdo Station within a few hours of their collection. Wet animal weight and gonad weight were taken, and a gonad index for each specimen was calculated by: gonad weight times 100 divided by animal wet weight. Sexes were distinguished by microscopic examination of gonadal smears. Food pellets in the gut and fecal pellets were squashed and inspected microscopically.

TABLE I

*Comparison of organic constitution in frozen and trichloroacetic acid (TCA) treated gonadal tissue of S. neumayeri in per cent per unit dry weight**

	Lipid	Carbohydrate	Lowry protein	Kjeldahl protein	Total nitrogen
Testes					
frozen	19.5 ± 1.8	14.1 ± 1.4	31.0 ± 9.0	21.2 ± 2.5	8.5 ± 0.7
TCA	20.0 ± 1.6	13.7 ± 0.9	33.8 ± 6.3	15.8 ± 3.9	8.2 ± 0.6
Ovaries					
frozen	26.1 ± 3.0	16.3 ± 3.8	32.0 ± 7.3	16.4 ± 3.0	6.7 ± 0.3
TCA	26.2 ± 2.6	15.5 ± 2.9	30.5 ± 6.3	12.6 ± 0.5	6.8 ± 0.4

* The sample consisted of 5 male and 5 female specimens collected on April 5, 1961, from Cape Evans, McMurdo Sound, Antarctica. Mean values are given with one standard deviation.

Small pieces of gonadal tissue were taken from each specimen and fixed in alcoholic Bouin's solution for 48 hours. These samples were dehydrated with acetone, cleared with benzene, and embedded and stored in paraffin. Sections (5 μ) were stained by Mallory's triple technique. The diameters of 50 oocytes, each with the nucleolus showing in section, were measured for each ovary sample, and the frequency of occurrence of the different-sized oocytes plotted as has been done for the asteroid *Odontaster validus* (Pearse, 1965).

For biochemical analyses, small pieces of the gonads, the ambulacral and interambulacral test areas at the ambitus with spines, the gut from the esophagus to the rectum, washed free of contents, and the gut contents were placed in small dishes and "fixed" with a few drops of 5% trichloroacetic acid. The tissue samples were dried either *in vacuo* over concentrated H_2SO_4 or in a closed chamber with air circulated continuously over the tissues and NaOH flakes. A few duplicate gonadal tissue samples were also frozen at $-70°$ C. and lyophilized. The samples were stored in sealed No. 2 tin cans with anhydrous $CaCl_2$ and shipped to Stanford University for biochemical analyses.

Total nitrogen in the tissues was determined by the Kjeldahl method (Markham, 1942). The protein in an aliquot of each tissue sample was precipitated in boiling 10% trichloroacetic acid and filtered. The nitrogen values (the non-protein nitrogen) in the filtrates determined by the Kjeldahl method were subtracted from the total nitrogen values obtained by assaying a piece of tissue to give estimates of the protein nitrogen values. Multiplication of the protein nitrogen values by the conversion factor 6.25 gave "Kjeldahl protein" values. Protein estimations were

TABLE II

*Animal sizes (gm.), gonad indices and organic constitution of the gonads (% dry weight) of S. neumayeri collected from McMurdo Sound, Antarctica during 1961**

	Wet animal weight	Gonad index	Lipid	Carbo-hydrate	Lowry protein	Total nitrogen
Cape Evans						
February 7						
males (3)	60.0±23.4	10.1± 3.8	23.9± 2.4	12.2± 1.4	32.9± 0.5	8.1±0.6
females (2)	33.0†	14.9†	23.5, 30.5	12.2, 14.9	36.3, 30.2	7.4, 6.4
April 5						
males (5)	44.4±20.8	24.9± 3.6	20.0± 1.6	13.7± 0.9	33.8± 6.3	8.2±0.6
females (5)	55.4±11.5	31.1± 4.5	26.2± 2.6	15.5± 2.9	30.5± 6.3	6.8±0.4
April 20						
males (2)	76.9, 33.3	37.1, 22.8	21.5, 22.1	19.1, 16.6	46.6, 31.8	—
female (1)	127.5	32.4	26.2	17.3	39.9	7.1
April 28						
females (2)	36.9†	38.8†	28.6, 30.7	13.3, 16.1	35.9, 32.5	6.8, 6.6
May 5						
males (2)	77.5, 38.1	34.7, 26.5	24.0, 16.7	13.9, 18.8	34.5, 31.8	7.8, 8.5
female (1)	42.0	39.9	24.2	13.4	31.5	6.9
December 7						
unsexable (1)	85.1	27.3	39.4	10.0	41.1	6.3
November 11						
female (1)	91.4	27.6	22.4	13.8	33.3	5.9
December 7						
female (1)	30.5	10.6	28.1	13.0	32.8	6.9
Turtle Rock						
December 6						
males (6)	17.3± 4.0	4.1± 2.2	16.7± 5.7	4.9± 1.9	33.5± 5.9	8.9±1.2
females (5)	20.6± 4.8	6.6± 1.6	30.3± 5.7	4.9± 1.2	33.4± 4.3	7.7±0.8

* The tissues were fixed with trichloroacetic acid. Individual values are given for samples of one or two animals while mean values with one standard deviation are given in parentheses.

† One animal accidentally crushed before being weighed.

also made by the Lowry method (Lowry *et al.*, 1951) after samples of the dried tissues were dissolved overnight in 1 N KOH, bovine serum albumin being used as a standard. Protein values estimated by this method are referred to as "Lowry Protein."

Lipid level in the tissues was determined by weight of the material extracted by the chloroform-methanol method (Freeman *et al.*, 1957). For carbohydrate extraction, the tissues were boiled for 10 minutes in 5% trichloroacetic acid and

centrifuged. Carbohydrate in the supernatant of these extracts was estimated colorimetrically by the phenol method of Dubois *et al.* (1956), using D-glucose as the standard.

Results

General habits and food

S. neumayeri occurred abundantly on basaltic gravel and rocks in water less than 15 m. in depth. The urchins were often seen with pebbles and bits of debris covering their tests. In the fall (April), when the air temperature was falling, anchor ice formed on much of the shallow bottom areas, and the urchins were often seen on this ice. Because some individuals were found preserved in perfect condition frozen into sea ice over 20 m. of water (Pearse, 1962a), these urchins probably are trapped occasionally in rising masses of anchor ice. Other large species of marine animals commonly found in association with *S. neumayeri* include the nemertean *Lineus corrugatus*, the gastropod *Neobuccinum eatoni*, the isopod *Glyptonotus antarcticus*, the asteroid *Odontaster validus* and the fish *Trematomus bernacchii*.

The average size of *S. neumayeri* collected from Turtle Rock was smaller than that of any others collected (Table II). These urchins, however, were the largest that could be taken by dipnet, and the population of *S. neumayeri* at Turtle Rock consisted of decidedly smaller animals than at either Cape Evans or Cape Royds.

At Cape Evans and Cape Royds large clumps of leafy red algae (*Iridaea* sp.) occurred frequently and may provide some food for *S. neumayeri*. However, between early February and April extensive carpets of diatoms grew on the shallow sea floor at Cape Evans. During this period the food of *S. neumayeri* consisted mainly of diatoms, the most conspicuous constituent of the food pellets in the gut. The fecal pellets from urchins collected at Cape Royds and Cape Evans in November and December also consisted mostly of diatom remains.

Turtle Rock was the site of a large rookery for Weddell seals (*Leptonychotes weddelli*), and in December, 1961, the sea floor in this area was littered with deposits of seal feces around which *S. neumayeri* aggregated. The gut of these specimens was filled with seal feces and contained relatively few diatoms.

Reproduction

The gonad indices of the samples taken from Cape Evans increased between early February and early May, and the specimens from the December 6 sample from Turtle Rock had the lowest gonad index recorded (Fig. 1, Table II). This change suggests that the gonads ripen and grow during the austral summer months and shrink following spawning during the winter or spring. However, as Holland and Giese (1965) found with *Strongylocentrotus purpuratus*, interpretation of echinoid gonad indices is sometimes difficult because of the large amounts of nutritive phagocytes in the gonads. The gonads of *S. neumayeri* also contain large numbers of these cells which are highly vacuolated (Figs. 2 and 3). Moreover, the single specimen of *S. neumayeri* of the December 7 Cape Evans sample had a high gonad index (27.3), but the gonads contained only a few gonial cells and great quantities of nutritive phagocytes. An increase in the gonad index there-

fore may reflect an increase of feeding with accumulation of food reserves in the nutritive phagocytes, possibly increasing the numbers of these cells, rather than an increase in gametogenic activity.

Histological sections of the gonads of *S. neumayeri* showed that oocytes of many sizes and spermatogenic cells in various stages, including spermatozoa, occurred in most of the samples (Figs. 2 and 3). The ovaries of the single female collected from Cape Royds on November 11 contained large numbers of ova ready for spawning (Fig. 2D), but there were also a few ova in the ovaries of one of the 5 females collected on April 5 from Cape Evans (Fig. 2B). Most of the testes contained spermatozoa. However, four of the 6 males collected on December 6

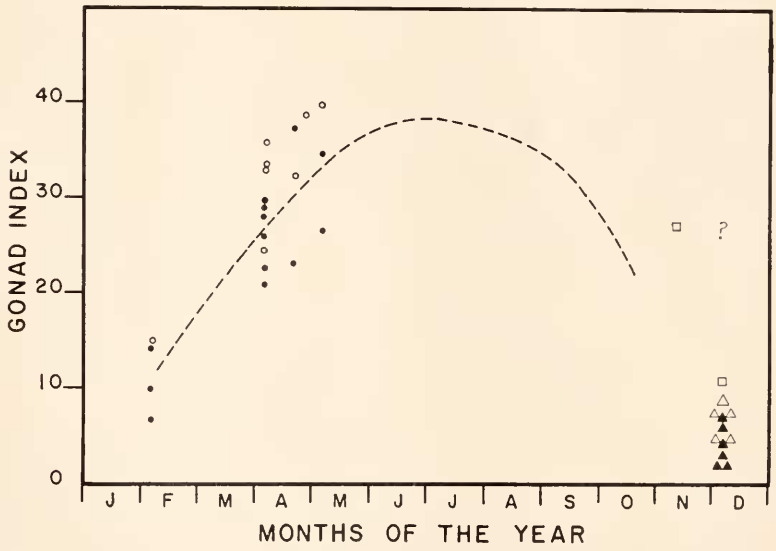

FIGURE 1. The gonad indices of *S. neumayeri* collected from McMurdo Sound during 1961. Samples came from Cape Evans (circles), Cape Royds (squares) and Turtle Rock (triangles). Solid symbols indicate males, open symbols indicate females and the "?" indicates a specimen of uncertain sex. The dotted line suggests possible changes in the gonad indices during the year.

from Turtle Rock were spawned out (Fig. 3F), and the other two had very small gonad indices although still retaining many spermatozoa (Fig. 3E). Many of the testicular sections showed regions with little or no spermatogenic activity next to areas of intense activity (Figs. 3B, C), which is unusual for echinoid testes. In both the ovaries and testes large numbers of nutritive phagocytes were always present. Because of the presence of gametes in different stages of development in almost all of the samples, and because of the large numbers of nutritive phagocytes, reproductive periodicities in *S. neumayeri* could not be delineated by casual inspection of the histological sections.

The change in frequency of oocytes of various sizes in the ovaries was much more revealing as to reproductive periodicities in *S. neumayeri*. Frequencies with

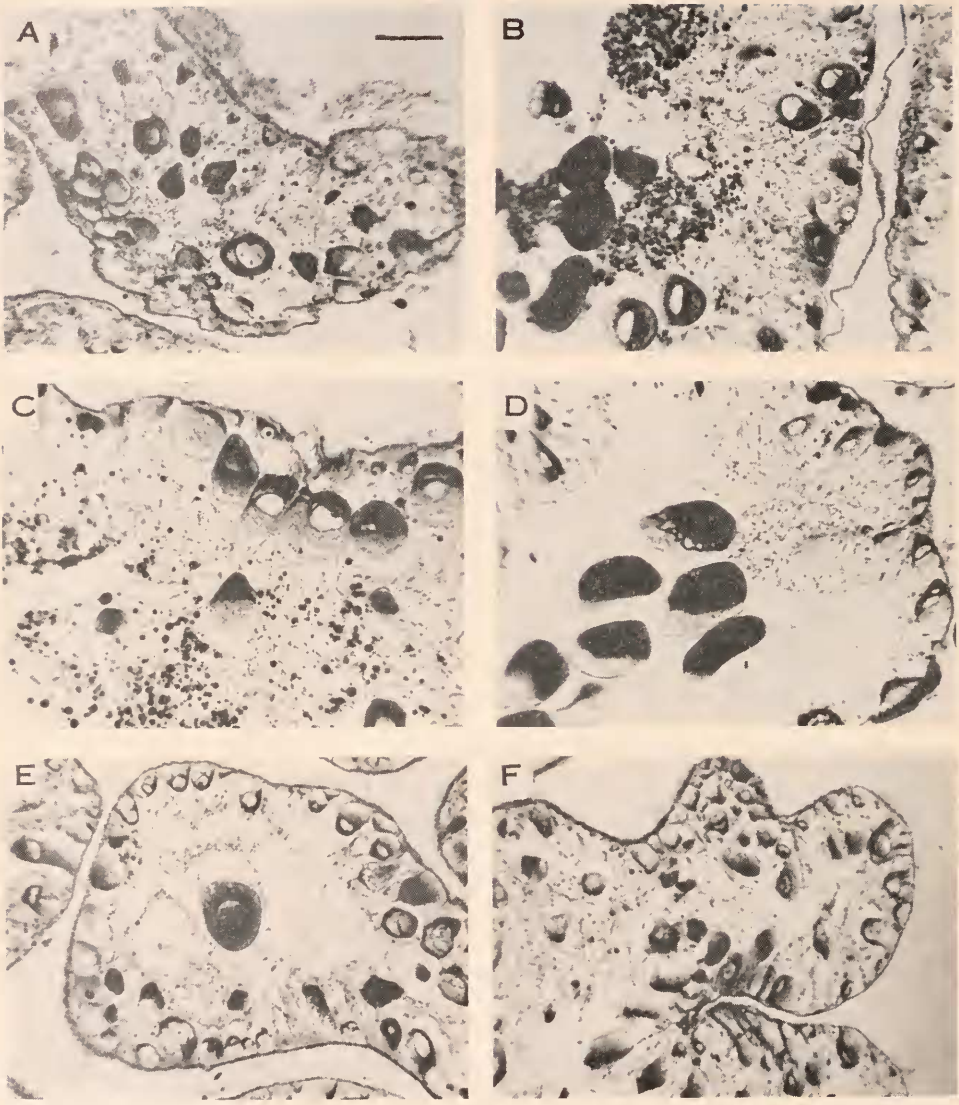

FIGURE 2. Histologic sections of ovaries from *S. neumayeri* collected at McMurdo Sound on February 7 (A), April 5 (B), May 5 (C), November 11 (D), December 7 (E), and December 6 (F), 1961. Samples for A–C were collected from Cape Evans, those for D and E were collected from Cape Royds, and the sample for F was collected from Turtle Rock. In all of the sections oocytes of various sizes occur scattered in the abundant vesicular nutritive phagocytic tissue, and ova are in the sections from the April and November samples. The scale line in A indicates 100 μ; A–F are shown at the same magnification.

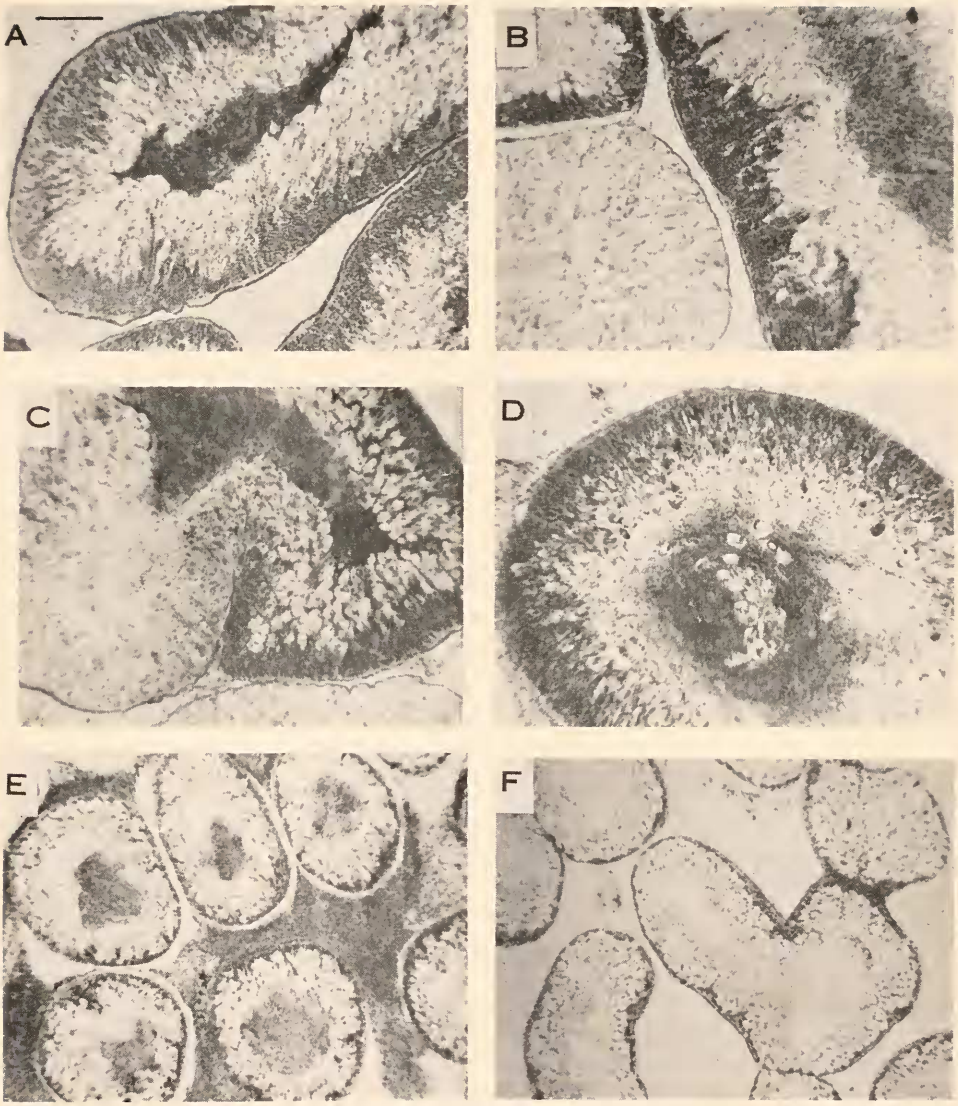

FIGURE 3. Histologic sections of testes from *S. neumayeri* collected at McMurdo Sound on February 7 (A), April 5 (B), April 20 (C), May 5 (D), and December 6 (E and F), 1961. Samples for A–D were collected from Cape Evans, and those for E and F were collected from Turtle Rock. Between February and May spermatogenesis was active among the abundant vesicular nutritive phagocytic tissue, and spermatozoa accumulated in the lumen, although as shown in B and C, spermatogenesis was not uniform along the germinal epithelium. In December the small testicular lobes contained little phagocytic tissue and spermatogenic activity was low, but the testes of some animals (*e.g.*, E) contained many spermatozoa. The scale line in A indicates 100 μ; A–F are shown at the same magnification.

which the oocytes of different sizes occur are shown in Figure 4 for all the ovary samples collected. The percentage of oocytes of any size was rather constant among individuals collected at the same time. In all the samples, except some of those from Turtle Rock, there was a clear demarcation which suggests an overlap

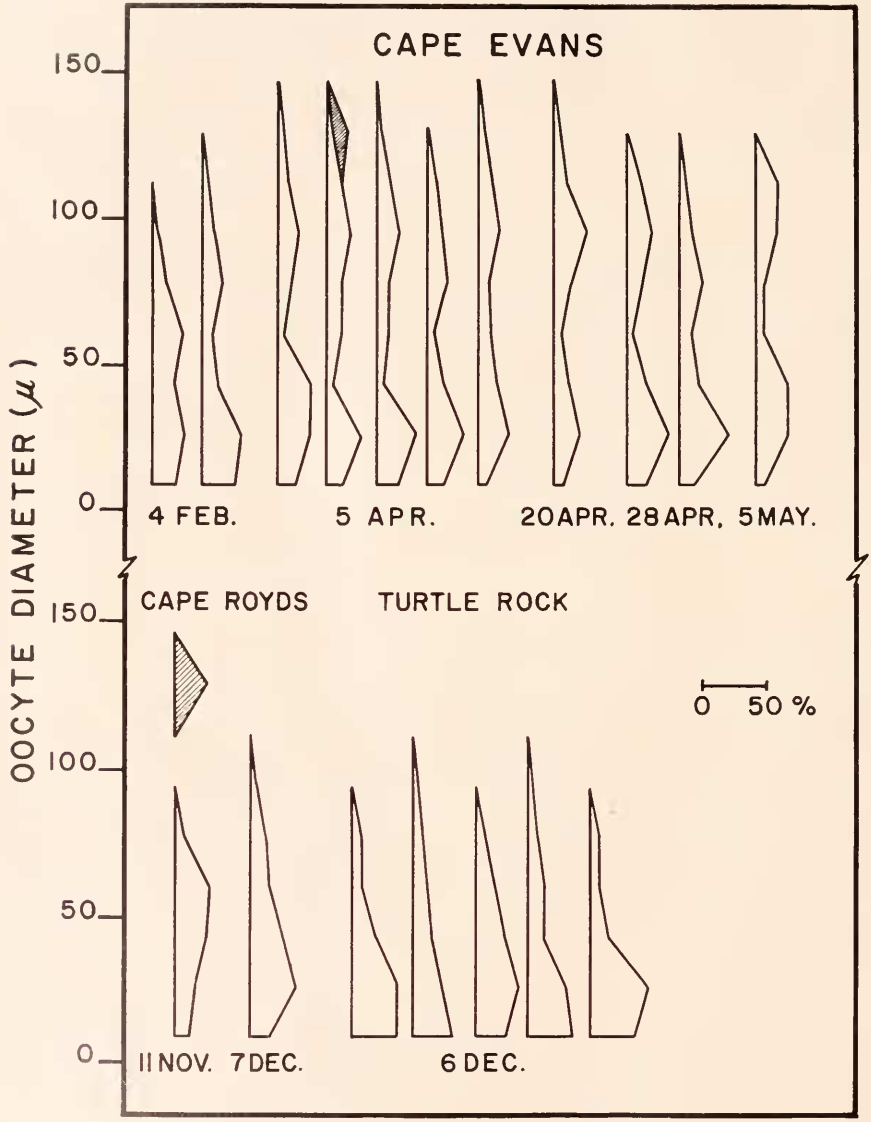

FIGURE 4. Polygons showing the frequencies (see scale) of different-sized oocytes in the ovaries of all the female specimens of *S. neumayeri* collected from McMurdo Sound during 1961. Hatched areas of the polygons represent ova; unhatched areas of the polygons represent primary oocytes.

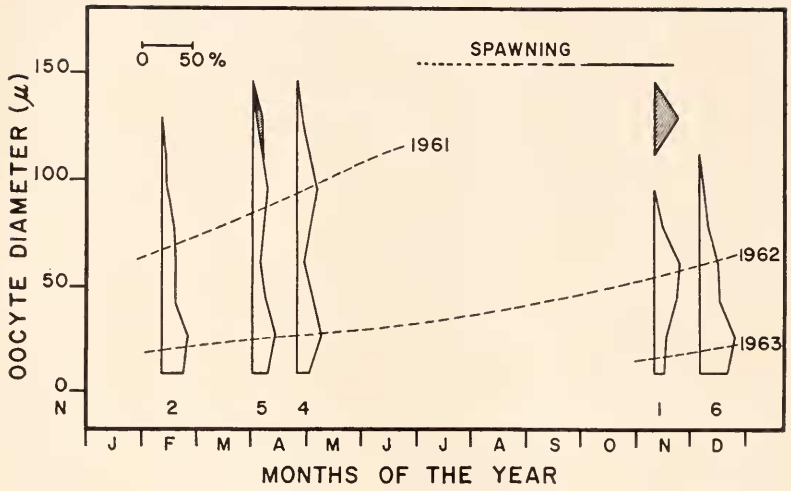

FIGURE 5. Polygons showing the oocyte frequencies (see scale) of different-sized oocytes in the ovaries of *S. neumayeri* averaged from samples collected from McMurdo Sound at different periods during 1961. The number of females averaged into each polygon is given as N. Hatched areas of the polygons represent ova; unhatched areas of the polygons represent primary oocytes. The dotted line suggests the rate of oocyte growth; "1961," "1962" and "1963" indicate the year the ova of each oocyte generation would presumably have spawned.

in two generations of oocytes, the small oocytes growing to maturity and being spawned a year after the spawning of the larger oocytes.

When the oocyte size frequencies of individuals collected during the same period were averaged and plotted through the year, a definite reproductive pattern became evident (Fig. 5). Very small oocytes appeared and began growth between November and May. As indicated in Figure 5, these young oocytes would mature into ova some 16 to 18 months after they began growth. A few ova were in the ovaries in April, and by November all the oocytes which had begun growth 18 to 24 months previously had matured into ova. Ova are therefore present in the ovaries between April and December; this is when spawning must occur.

Three generations of oocytes could be distinguished in the samples collected, as shown in Figure 5. Present are: (1) the oocytes which began growth in 1959–60 and would have been spawned in 1961, (2) those which began growth in 1960–61 and would have been spawned in 1962, and (3) part of those which would have begun growth in 1961–62 and would have been ready for the spawning period of 1963. In the November 11 sample from Cape Royds, all three of these oocyte generations could be distinguished; the oocytes of the 1961 spawning season had matured into ova ready for spawning, the oocytes for the 1962 spawning season had mostly reached one-third to one-half the diameter of full growth, and a few oocytes of the 1963 spawning season had just begun growth.

It is interesting to note that unlike the samples from Cape Evans and Cape Royds, there were many more small oocytes than large oocytes in the ovaries of the Turtle Rock sample (Fig. 4). The presence of a large number of small oocytes without a corresponding large number of the larger oocytes which had

begun growth 8 to 12 months earlier suggests that many of the oocytes in specimens at Turtle Rock began growth only to be destroyed before they were a year old.

The individuals of the February 7 and April 5 samples were injected through the peristome with sea water saturated with KCl soon after collection. Two males and one female of the February 7 sample so treated spawned a few mature gametes but none of the individuals of the April 5 sample spawned. Some of the ova were fertilized when mixed with the spawned spermatozoa. The resulting zygotes were kept in sea water in a refrigerator at $-1.5 \pm 1°$ C., but after a few unequal, abnormal-appearing cleavages, division stopped. Inasmuch as no mature ova were seen in the histological sections of the spawning female, it is uncertain whether the few ova obtained were residual ova or a precocious development for the forthcoming season.

Organic constitution of the tissues

With respect to lipid, carbohydrate, Lowry protein and total nitrogen no difference was detected between gonadal tissue prepared by freezing and drying and by fixing with trichloroacetic acid and desiccator-drying. Protein determined by the Kjeldahl method, however, was always higher in the frozen, dried tissues than in the trichloroacetic acid-treated, dried tissues (Table I).

The Lowry method gave higher, though more variable, protein values than the Kjeldahl method (Table I). Holland (1964) attributed the low Kjeldahl protein values for the coelomic fluid of *Strongylocentrotus purpuratus* as the result of incomplete precipitation of protein. The protein values obtained by the Lowry method are thus considered more realistic than those by the Kjeldahl method.

The lipid, carbohydrate, protein and total nitrogen levels of the gonadal samples of *S. neumayeri* are given in Table II. No seasonal change in the percentages of any of these constituents could be detected. The February to May Cape Evans samples had about the same levels of these constituents as the November and December Cape Evans and Cape Royds samples. However, as noted previously, there was a definite increase between early February and early May in gonadal size as expressed by the gonad indices (Fig. 1, Table II), so that on an absolute basis, the amounts of all the constituents measured increased during this period.

There was much less carbohydrate in the gonadal samples from Turtle Rock than in those from Cape Evans and Cape Royds. The lipid level in the testis samples from Turtle Rock was also unusually low. The difference in carbohydrate levels in the gonads was probably dependent on local factors, not on seasonal change, because it was also noticeable between the December 6 Turtle Rock sample and the December 7 Cape Evans and Cape Royds samples.

Sexual differences were found in the lipid and total nitrogen levels of the gonads. The ovaries usually contained much more lipid than the testes, this difference being especially marked in the sample from Turtle Rock. The testes always contained more total nitrogen than the ovaries. Because there was essentially no sex difference in the amounts of protein in the gonads, the higher total nitrogen content of testes was attributed to higher non-protein nitrogen content in the testes than in the ovaries.

The gonads of the specimen collected on December 7 from Cape Evans had the highest lipid levels and the lowest total nitrogen levels of any specimen sampled.

As the gonads consisted mainly of nutritive phagocytes with only a few gonial cells, their sex could not be determined. They had a histologic appearance similar to the inactive testicular lobes shown in Figure 3B and C. However, the high lipid and low total nitrogen content in these gonads was characteristic of the ovaries of the other samples.

Table III gives the lipid, carbohydrate, protein and total nitrogen levels in the samples of test, gut and gut contents. Although most of the specimens used for these determinations came from Turtle Rock, no differences could be detected between the Turtle Rock specimens and those from Cape Evans and Cape Royds. The body wall, with its high amount of calcium carbonate, contained very low percentages of organic constituents. The gut tissue was similar to the gonadal

Table III

*Organic constitution of the test, gut and gut contents of S. neumayeri collected between November and early December, 1961, from McMurdo Sound, Antarctica**

	Lipid	Carbohydrate	Lowry protein	Total nitrogen
Test	2.5 ± 0.4 (14)	0.6 ± 1.0 (14)	6.1 ± 2.4 (10)	1.2 ± 0.2 (14)
Gut	24.9 ± 5.3 (14)	3.0 ± 0.5 (12)	35.9 ± 6.8 (8)	8.7 ± 0.8 (14)
Gut contents	12.1 ± 7.0 (7)	2.0 ± 0.7 (8)	—	3.0 ± 2.3 (7)

* The tissues were fixed with trichloroacetic acid. Mean values are given in per cent dry tissue weight with one standard deviation. The number of animals sampled for each value is given in parentheses.

tissue of the Turtle Rock sample. The gut contents, consisting of partly digested pellets of seal feces and diatoms, contained lower percentages of lipid, carbohydrate and total nitrogen than the gut tissue.

Discussion

The common Antarctic echinoid *S. neumayeri* is similar to regular echinoids in other parts of the world in many respects besides appearance. Specimens often cover their tests with debris as do many other echinoids (Nichols, 1964). Like many other echinoids that have been studied (Hyman, 1955, pp. 558–589; Nichols, 1964), *S. neumayeri* is largely herbivorous, feeding mostly on diatoms. In this respect it resembles the Californian deep-sea echinoid *Allocentrotus fragilis* (Boolootian *et al.*, 1959; Giese, 1961). In both species this diet is probably the result of the ready availability of diatoms. The occasional seal-feces diet of *S. neumayeri*, however, is unique for an echinoid, but the omnivorous Antarctic asteroid *Odontaster validus* also feeds on seal feces when these are available (Pearse, 1965).

S. neumayeri appears to have relatively well defined reproductive periodicities as do many other echinoids (*e.g.*, as reported by Moore, 1934; Stephenson, 1934; Yoshida, 1952; Harvey, 1956; Fuji, 1960; McPherson, 1965; Holland and Giese, 1965). Even the tropical echinoid *Stomopneustes variolaris* shows periodic differences in breeding intensity though mature gametes occur all year (Giese *et al.*, 1964). The oogenic growth period of well over a year in *S. neumayeri* is similar to that of the Californian echinoid *Strongylocentrotus purpuratus* (Holland and

Giese, 1965). Many echinoids besides *S. neumayeri* also have large numbers of nutritive phagocytes in the gonads (*e.g.*, Caullery, 1925; Fuji, 1960; Holland and Giese, 1965) but in the gonads of *S. neumayeri* these cells seem to be especially abundant.

The differentiation and beginning of growth of the oocytes of *S. neumayeri* probably occur between November and May. This period is the austral summer when phytoproduction occurs (Littlepage, 1965). However, in December the sea temperature increases slightly in McMurdo Sound (Littlepage, 1965) and, as with the asteroid *O. validus* (Pearse, 1965), it is impossible to tell at present whether the increased temperature or phytoproduction, or neither or both, may play a role in synchronizing gametogenesis.

The gonads of *S. neumayeri* grow in size during the summer period of phytoproduction. Part of this growth is undoubtedly attributable to active gametogenesis, but part also appears to be the result of accumulation of nutrients in the nutritive phagocytes of the gonads. Because oocyte growth continues in the winter when no phytoproduction occurs, stores in the nutritive phagocytes must then be utilized for gametogenesis. The nutritive phagocytes thus appear to serve the same function as the pyloric caeca in the asteroid *O. validus* (Pearse, 1965).

S. neumayeri spawns sometime between May and December. This period is the austral winter and spring when there is little or no phytoproduction (Littlepage, 1965). The relatively small size (about 125 μ in diameter) of the ova of *S. neumayeri*, however, suggests that this species develops indirectly with feeding echinoplutei. Mortensen (1913), moreover, has described echinoplutei from Antarctica (Gauss Berg, 65°S., 90°E.) as those of *S. neumayeri*. These larvae were collected between December and early March, and those collected between February and March were in late stages of development. MacBride and Simpson (1908) also described two metamorphosing larvae (*Echinopluteus antarcticus*) collected from McMurdo Sound in January and February which Mortensen (1913) believed were those of *S. neumayeri*. *S. neumayeri* therefore probably has feeding echinopluteus larvae which occur in the summer even though spawning occurs in the winter or spring. As previously reported (Pearse, 1962a, 1962b, 1965), the asteroid *O. validus* spawns in mid-winter at McMurdo Sound, its embryos develop very slowly, and the feeding bipinnaria larvae are consequently present in the spring and summer months when plant food is available. It seems probable that this pattern of winter or spring spawning, very slow embryonic development, and the occurrence of feeding larvae in the summer when plant food is available characterizes *S. neumayeri* also.

Although *S. neumayeri* is very common in McMurdo Sound, and most likely has an echinopluteus larva, plankton samples taken bi-weekly or monthly from McMurdo Station during all of 1961 failed to reveal any echinoplutei (J. L. Littlepage, personal communication). If, indeed, *S. neumayeri* has an echinopluteus larva, these larvae, like those of *Odontaster validus* (Pearse, 1965), must be mostly demersal in habit. In this respect, it is noteworthy that 40 of the 46 specimens of *S. neumayeri* echinoplutei that Mortensen (1913) records were collected from depths of 100 m. or more.

The organic constitution of the tissue of *S. neumayeri* is not unusual in comparison with that of other echinoids studied (Giese, 1966). The levels of lipid,

protein and total nitrogen in the gonads, gut and test tissues are very similar to those of other echinoids. Also, as in other echinoids, the ovaries of *S. neumayeri* contain more lipid than the testes, probably because it is accumulated in the oocytes. On the other hand, as in other echinoids, there is more non-protein nitrogen in the testes than in the ovaries, presumably because of the higher DNA level in the sperm. The carbohydrate level in the gonadal tissues of *S. neumayeri* from Cape Evans and Cape Royds is considerably higher than in most other echinoids, including *Strongylocentrotus purpuratus, S. franciscanus* and *Allocentrotus fragilis* (Giese, 1966), but it is somewhat lower than that reported in *Echinus esculentus* by Stott (1931).

Several differences were noted in this study between the specimens of *S. neumayeri* from Turtle Rock and those from Cape Evans and Cape Royds. The specimens at Turtle Rock were much smaller and their gonads contained much less carbohydrate than those from Cape Evans and Cape Royds. Moreover, there appeared to be considerable breakdown of oocytes in the ovaries of the animals from Turtle Rock while little or no oocyte breakdown occurred in the ovaries of animals from Cape Evans and Cape Royds. These differences among the populations of *S. neumayeri*, suggesting less favorable conditions at Turtle Rock, are in accord with other differences noted among the fauna of Cape Evans and areas further south in McMurdo Sound. Thus, the gastropod *Neobuccinum eatoni* was abundant at Cape Evans but was not seen at McMurdo Station which is south of both Cape Evans and Turtle Rock, and the nemertean *Lineus corrugatus* was smaller and contained less carbohydrate at McMurdo Station than at Cape Evans (Pearse and Giese, 1966). The asteroid *Odontaster validus* was smaller, less abundant and contained less red-orange integumentary pigment at both McMurdo Station and Turtle Rock than at Cape Evans and Cape Royds (Pearse, 1965). Further, the pyloric caeca of *O. validus* at Cape Evans increased in size by accumulating lipid, carbohydrate, protein and a green chlorophyll derivative during the summer months, while no such changes occurred in the pyloric caeca of *O. validus* at McMurdo Station. Many more gametes were also produced in the specimens of *O. validus* at Cape Evans than in those at McMurdo Station. From a consideration of the differing seasonal amounts of ice cover in McMurdo Sound, Pearse (1965) suggested that much more phytoproduction occurs at Cape Evans and areas further north than in more southerly areas such as at Turtle Rock and McMurdo Station. The differences noted among the populations of *S. neumayeri* in the present study, as well as those among the populations of *N. eatoni, L. corrugatus* and *O. validus*, suggest that the differences in phytoproduction are probably reflected in the fauna.

Summary

1. The common Antarctic echinoid *Sterechinus neumayeri* (Meissner) feeds mostly on diatoms, although such things as seal feces are also used for food when available.

2. Specimens of *S. neumayeri* in McMurdo Sound have discrete reproductive periodicities as do most echinoids in other parts of the world. Oocyte growth begins in the summer between November and May, the oocytes take from 18 to 24 months to reach maturity after beginning growth, and spawning occurs sometime

in the winter or spring between May and December. The embryos presumably develop slowly into demersal echinopluteus larvae in the summer when plant food is available.

3. Nutrients seem to be accumulated in the nutritive phagocytes of the gonads during the summer when phytoproduction occurs, and the gonads increase in size during this period. These nutrients are probably utilized during the winter to maintain a relatively constant rate of gametogenesis.

4. The lipid, carbohydrate, protein and total nitrogen levels in the gonads, test, gut and gut contents of *S. neumayeri* are similar to those of other echinoids, although the carbohydrate content in the gonads is generally higher than in most other echinoid gonads that have been studied.

5. Differences among the populations of *S. neumayeri* in McMurdo Sound support an earlier suggestion that food conditions are better at Cape Evans and farther north than they are south of Cape Evans.

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